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HARD-TOP CONVERTIBLE ROOF SYSTEM

BACKGROUND AND SUMMARY OF THE INVENTION

[0001] This invention relates generally to automotive roof systems and more particularly to a convertible roof system for an automotive vehicle.

[0002] Rigid hard-top convertible roofs have been used on a variety of automotive vehicles. Some of these conventional convertible hard-top roofs are stored in a generally vertical orientation and some are stored in a predominantly horizontal orientation. Furthermore, some of these conventional hard-top roofs fold in a clamshelling manner while others are collapsible in an overlapping manner. Most convertible hard-top roofs, however, employ a complicated linkage arrangement to couple the forwardmost hard-top roof section to either the vehicle body or the rear hard-top roof section. This is often due to the weight and moment-arm effect of the front roof section during retraction. For example, many of these known mechanisms use an elongated balance link coupling the body to the front roof section, or an elongated sliding or track guide secured to the vehicle body and coupled to a link; notwithstanding, such mechanisms may pose packaging and assembly obstacles in the typically tight confines of the vehicle body. Additionally, many of these traditional roof sections are difficult to tightly

nest together in a stowed position in order to minimize the convertible roof storage space in the vehicle.

[0003] Examples of traditional hard-top convertible roofs are disclosed in the following patents: U.S. Patent No. 5,979,970 entitled "Roof Assembly for a Convertible Vehicle" which issued to Rothe et al. on November 9, 1999; U.S. Patent No. 5,785,375 entitled "Retractable Hard-Top for an Automotive Vehicle" which issued to Alexander et al. on July 28, 1998; U.S. Patent No. 5,769,483 entitled "Convertible Motor Vehicle Roof" which issued to Danzl et al. on June 23, 1998; U.S. Patent No. 5,743,587 entitled "Apparatus for Use in an Automotive Vehicle having a Convertible Roof System" which issued to Alexander et al. on April 28, 1998; and EPO Patent Publication No. 1 092 580 A1 which was published on April 18, 2001. The U.S. patents are incorporated by reference herein.

[0004] In accordance with the present invention, a convertible roof system includes a front roof section, a rear roof section, an automatically power actuator and a linkage mechanism. In another aspect of the present invention, the front and/or rear roof sections are rigid, hard-top roofs. A further aspect of the present invention provides that the outside surfaces of the roofs have a generally vertical orientation when in their open and retracted positions. In yet another aspect of the present invention, a linkage assembly having at least a four-bar linkage arrangement couples the front roof section to the rear roof section. The convertible roof system employs another linkage assembly having

at least a four-bar linkage arrangement which couples the rear roof section to the vehicle body, in still another aspect of the present invention. A further aspect of the present invention provides that a single link adjacent to each outboard side of the front roof is the sole mechanism which couples together the hard-top front roof to the rear roof and the top stack mechanism. Another aspect of the present invention uses a rigid tonneau cover and tonneau cover linkage mechanism to cover a roof storage space which does not obstruct a trunk or bed area of the vehicle. In a further aspect of the present invention, a supplemental automatic actuator is operable to more closely store together the fully retracted front and rear roof sections.

[0005] The hard-top convertible roof system of the present invention is advantageous over conventional systems in that the present invention minimizes the stored roof packaging area by tightly collapsing one roof section relative to the other. The present invention convertible roof system is also advantageous by employing a relatively powerful and easy to package linkage mechanism that allows for collapsing of the relatively heavy hard-top roof sections with minimal, if any, intrusion on the passenger compartment area of the vehicle while also storing the roof forward of a user accessible storage area, such as a trunk or pickup truck bed. Furthermore, the present invention does not require as great a centerline opening for the roof storage area as do many traditional hard and soft-top convertible roofs. The convertible roof system of the present invention is also simpler and less costly to assemble to the vehicle body since fewer body

attachment points are used. Additional advantages and features of the present invention will become apparent from the following description and appended claims, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Figure 1 is a fragmentary, perspective view, as observed from the rear left corner of the vehicle, showing the preferred embodiment of a hard-top convertible roof system of the present invention disposed in a fully closed and raised position;

[0007] Figure 2 is a fragmentary and perspective view, like that of Figure 1, showing the preferred embodiment hard-top convertible roof system disposed in a partially retracted position;

[0008] Figure 3 is a fragmentary and perspective view, like that of Figure 1, showing the preferred embodiment hard-top convertible roof system disposed in a fully open and retracted position;

[0009] Figure 4 is a perspective view, like that of Figure 1, showing a top stack mechanism employed in the preferred embodiment hard-top convertible roof system, disposed in a fully raised position;

[0010] Figure 5 is a side diagrammatic view showing the top stack mechanism and a tonneau cover mechanism employed in the preferred embodiment hard-top convertible roof system, disposed in the fully raised roof and closed tonneau cover positions;

[0011] Figure 6 is a perspective view, like that of Figure 1, showing the top stack mechanism employed in the preferred embodiment hard-top convertible roof system, disposed in a partially retracted position;

[0012] Figure 7 is a side diagrammatic view showing the top stack mechanism employed in the preferred embodiment hard-top convertible roof system, disposed in the partially retracted position;

[0013] Figure 8 is a perspective view, like that of Figure 1, showing the top stack mechanism employed in the preferred embodiment hard-top convertible roof system, disposed in the fully retracted position;

[0014] Figure 9 is a side diagrammatic view showing the top stack mechanism employed in the preferred embodiment hard-top convertible roof system, disposed in the fully retracted position;

[0015] Figure 10 is a centerline cross sectional view, taken along line 10-10 of Figure 3, showing the preferred embodiment hard-top convertible roof system;

[0016] Figure 11 is a front perspective view showing the tonneau cover mechanism employed in the preferred embodiment hard-top convertible roof system, disposed in a partially open position;

[0017] Figure 12 is a side elevational view showing the tonneau cover mechanism employed in the preferred embodiment hard-top convertible roof system, disposed in a fully closed position;

[0018] Figure 13 is a side elevational view showing the tonneau cover mechanism employed in the preferred embodiment hard-top convertible roof system, disposed in a partially open position;

[0019] Figure 14 is a side elevational view showing the tonneau cover mechanism employed in the preferred embodiment hard-top convertible roof system, disposed in a fully open position;

[0020] Figure 15 is a side elevational view showing an alternate embodiment hard-top convertible roof system of the present invention disposed in a fully closed position;

[0021] Figure 16 is a side diagrammatic view showing a top stack mechanism employed in the alternate embodiment hard-top convertible roof system, disposed in a partially retracted position;

[0022] Figure 17 is a side diagrammatic view showing the top stack mechanism employed in the alternate embodiment hard-top convertible roof system, disposed in a further partially retracted position;

[0023] Figure 18 is a side diagrammatic view showing the top stack mechanism in the alternate embodiment hard-top convertible roof system, disposed in a fully retracted position; and

[0024] Figure 19 is an enlarged side elevational view showing a supplemental automatic actuator of the top stack mechanism employed in the alternate embodiment hard-top convertible roof system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0025] Referring to Figures 1-3 and 10, a convertible roof system 21 is part of an automotive vehicle and includes a hard-top front roof 23, a hard-top rear roof 25, a top stack mechanism 27 operable to move the roofs, a rigid tonneau cover 29 and a tonneau cover mechanism 31. Roofs 23 and 25 are automatically movable from fully raised and closed positions covering a passenger compartment 33, as shown in Figure 1, to fully retracted and open positions, as shown in Figures 3 and 10, wherein roofs 23 and 25 are stowed in a roof storage area or compartment 35. Roof storage compartment 35 is located between and physically separated by metal panels 36 (see Figure 9) from passenger compartment 33 and an externally accessible storage area for miscellaneous articles such as a trunk or pickup truck bed 37. A rigid, glass back window or backlite 39 is secured to rear roof 25 while front roof 23 is disengagably attached to a front header panel 41 by latches. Weatherstrips or seals are also employed around the peripheral edges of roofs 23 and 25. Roofs 23 and 25 are preferably stamped from aluminum or steel sheets and include inner reinforcement panels, but the roofs may alternately be formed from polymeric composites. Roofs 23 and 25 have opaque outside surfaces 43 that are typically painted. These outside surfaces 43 define three-dimensionally curved planes which are stored in a predominantly vertical and parallel nested orientation when fully retracted and stowed; this can be observed best in Figures 9 and 10.

[0026] Top stack mechanism 27 is in mirrored symmetry in both outboard sides of the vehicle and will only be described for the left-hand side with reference to Figures 4 through 9. Top stack mechanism 27 includes a first four-bar linkage assembly 51, a second four-bar linkage assembly 53 and a primary hydraulic actuator 55. First, four-bar linkage assembly 51 couples front roof 23 to rear roof 25 and includes a pair of somewhat parallel links 57 and 59 (as viewed in Figures 6 and 7) pivotally attached to a rear roof-mounted plate 61. The opposite ends of links 57 and 59 are pivotally joined to a single link 63 which rearwardly extends from front roof 23 and is attached to an outboard side rail area of front roof 23. Single link 63 can alternately be considered a rearwardly extending bracket bolted to the side rail reinforcement structure of the front roof.

[0027] Second four-bar linkage assembly 53 couples rear roof 25 to the vehicle body 71 by way of a stationarily mounted bracket 73 welded, bolted or otherwise secured to an inner quarter panel or the like. Second four-bar linkage assembly 53 includes a pair of somewhat parallel links 75 and 77 (as viewed in Figures 6 and 7) which each have a proximal end pivotally coupled to bracket 73. A distal end of link 75 is pivotally coupled to plate 61 attached to rear roof 25. A distal end of link 77 is enlarged and is pivotally attached to plate 61.

[0028] An end of a linearly extendable piston rod 79 of hydraulic actuator 55 is pivotally coupled to an intermediate or middle section of link 77. Furthermore, a control linkage mechanism couples together first and second four-bar linkages, respectively 51 and 53. Control linkage mechanism includes a

first drive link 81 and a second drive link 83 pivotally coupled to the first drive link. An end of first drive link 81 is pivotally coupled to the enlarged section of link 77 while an end of drive link 83 is pivotally coupled to a middle or intermediate section of link 57. A hydraulically actuated rotary actuator 85 has a housing mounted to the enlarged section of link 77 and has a rotatable output gear or shaft which engages a splined receptacle of link 81 and operably causes link 81 to rotate relative to link 77. Rotary actuator 85 can be obtained from either Power Packer Co. of Germany or Hoerbriger Co. of Germany.

[0029] Roofs 23 and 25 can be tightly and closely nested together when fully retracted and the centerline, fore-and-aft roof storage area opening can be minimized due to the four-bar linkages 51 and 53, rotary actuator 85 and links 81 and 83. Furthermore, the four-bar linkage arrangements provide for very powerful and balanced movement, both between the vehicle body and the rear roof, and also between the roofs themselves, with very compact retracting and advancing space and with relatively short and tightly packaged links. Accordingly, only a single link attaches each outboard edge of front roof 23 to the remainder of the top stack mechanism and no difficult to package balance links are required with this preferred embodiment system. Guides, tracks and cables are also not necessary with the presently preferred embodiment since the present invention can be very easily mounted to the vehicle through the easy to attach bracket 73 and hydraulic actuator 55 body mounting. This non-guide construction also reduces side-to-side binding during roof movement. It should

be appreciated, however, that a balance link, extra front roof attachments or guides can be alternately employed, but certain advantages of the present invention would be sacrificed.

[0030] A tonneau cover mechanism 101 and tonneau cover 29 are best shown in Figures 11-14; only one side will be discussed since the other is symmetrical. Tonneau cover mechanism 101 includes a scissor linkage assembly 103 having an arcuate gooseneck link 105, a pair of parallel links 107 and 109, a follower gooseneck link 111 and a straight trailing link 113. A hydraulic actuator 115 has a cylinder end 117 pivotally coupled to a distal end of follower gooseneck link 111 and an intermediate section of gooseneck link 105. An end of a linearly extendable piston rod 119 of actuator 115 is pivotally coupled between projecting walls of a stationary, body-mounted bracket 121. Proximal ends of gooseneck link 105 and follower gooseneck link 111 are also pivotally coupled to bracket 121. A proximal end of trailing link 113 is similarly pivotally coupled to bracket 121. A distal end of trailing link 113 is pivotally attached to link 109. An opposite end of link 109 is pivotally mounted to an L-shaped support 131 which, in turn, is fastened to an inside surface of tonneau cover 29. Link 107 also has a first end pivotally coupled to support 131 and an opposite end pivotally attached to a straight distal end of gooseneck link 105.

[0031] Tonneau cover mechanism 101 defines a six-bar linkage arrangement. Accordingly, when a hydraulic pump 133 (see Figure 5) is energized, tonneau cover mechanism 101 will cause tonneau cover 29 to

vertically raise while simultaneously rearwardly pivoting from the closed position of Figure 12 to the open position of Figure 14. This allows roofs 23 and 25 to enter roof storage area 35 (see Figures 2 and 9). Tonneau cover 29 will be automatically returned to its closed position in order to cover and externally hide the stowed roofs. All of the top stack mechanism actuators and tonneau cover actuators may be controlled in accordance with the control system disclosed in U.S. Patent No. 5,451,849 entitled "Motorized Self-Correcting Automatic Convertible Top" which issued to Porter et al. on September 19, 1995, which is incorporated by reference herein.

[0032] An alternate embodiment hard-top convertible roof system is illustrated in Figures 15-19. A hard-top front roof 223 and a hard-top rear roof 225 are movable from a fully raised position, as shown in Figure 15, to a fully retracted and open position, as shown in Figure 18, by way of a top stack linkage mechanism 227. Top stack mechanism 227 includes three primary links 251, 253 and 255 which all have proximal ends pivotally attached to a stationary, body-mounted bracket 273. A secondary linkage mechanism of top stack mechanism 227 includes a curved forward link 257 and a rear link 259. Rear link 259 has an enlarged end section 261 with an arcuately shaped camming surface or slot 263. Distal ends of primary links 253 and 255 are pivotally coupled to enlarged section 261 of rear link 259. Rear roof 225 is coupled to rear link 259 and the primary links 253 and 255 at pivot points 265 and 267.

[0033] A supplemental actuator 269 has a first end pivotally secured to rear link 259 at a fixed pivot axis 271; this can best be observed by reference to Figure 19. Supplemental actuator 269 is preferably a relatively small hydraulic cylinder having a linearly movable piston rod 275 with a rod end attached to pivot 267 of rear roof 225 (see Figure 16). Thus, pivot 267 acts as a cam follower relative to camming slot 263, whereby energization of actuator 269 causes rear roof pivot 267 to move along the camming slot path in order to rotate rear roof about the fixed pivot axis corresponding to pivot 265. This movement serves to further tighten the nested front and rear roofs and minimize their required fore-and-aft packaging space when in the stored position shown in Figure 18. In other words, retracted actuation of primary hydraulic actuator 301 will cause the gross retracted movement from the position shown in Figure 15 to that shown in Figure 17. Primary actuator 301 will further cause top stack mechanism 227 to completely collapse to its retracted position. Supplemental actuator 269 will automatically provide fine motion control of rear roof 225 when top stack mechanism 227 is moved between the positions shown in Figures 17 and 18. The final retracted forward rotation of rear roof 225 is caused by energization of supplemental actuator 269 which enables rear roof 225 to become much closer to the fully retracted front roof 223 and provide a smaller stowed package. Reverse advancing movement is opposite that described. If desired, this fine supplemental movement can alternately occur concurrently while the rear roof is also moving through the body opening of the roof storage space.

[0034] It should be appreciated that this supplemental fine movement motion can also be applied to a fabric covered, soft-top roof or to a horizontally stowed hard-top roof system. Exemplary soft-top roofs are disclosed in U.S. Patent Nos. 5,903,119 entitled "Convertible Roof Actuation Mechanism" which issued to Laurain et al. on May 11, 1999, and 5,772,274 entitled "Motorized Drive System for a Convertible Roof of an Automotive Vehicle" which issued to Tokarz on June 30, 1998, both of which are incorporated by reference herein. The supplemental actuator would have the cylinder attached to one link and the end of the piston rod attached to another link.

[0035] A bellcrank 311 has a central pivot 313 attached to an intermediate section of roof link 259. A short offset bellcrank arm 315 has an end pivotally coupled to a distal end of primary link 251 while an end of an elongated bellcrank arm 317 is pivotally coupled to a front roof bracket 319 or roof inner structure. Front roof bracket 319 is also pivotally coupled to an end of forward link 257. Accordingly, energized movement of primary actuator 301 causes primary link 255 to rotate rear link 259 and rear roof 225 about pivot 265. This motion further causes bellcrank 311 to be rotated by primary link 251 relative to rear link 259. This bellcrank motion serves to rotate and collapse front roof 223 relative to rear roof 225.

While various embodiments of the hard-top convertible roof system have been disclosed, it should be appreciated that variations may be made to the present invention. For example, additional or fewer links may be employed in the

presently disclosed top stack mechanisms. Furthermore, the hard-top roofs can be covered with vinyl, fabric or painted, or can include transparent glass panels. Moreover, electric motor actuators can be used in place of one or more of the disclosed hydraulic actuators. It should also be appreciated that the trunk compartment can be in front of the passenger compartment for a mid or rear engine vehicle. While various materials and shapes have been disclosed, it should be appreciated that various other shapes and materials can be employed. It is intended by the following claims to cover these and any other departures from the disclosed embodiments which fall within the true spirit of this invention.